WADC TECHNICAL REPORT 52-183
SUPPLEMENT 5
ASTIA DOCUMENT AD 142081

ANNUAL REPORT ON RESEARCH FOR USE IN ANC-17 BULLETIN "PLASTICS FOR AIRCRAFT"

DONALD G. COLEMAN

FOREST PRODUCTS LABORATORY

OCTOBER 1957

This report is not to be announced or distributed automatically in accordance with AFR 205-43A, paragraph 6d.

WRIGHT AIR DEVELOPMENT CENTER

Statement A
Approved for Public Release

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

- - - - -

Qualified requesters may obtain copies of this report from the ASTIA Document Service Center, Knott Building, Dayton 2, Ohio.

- - - - -

Copies of WADC Technical Reports and Technical Notes should not be returned to the Wright Air Development Center unless return is required by security considerations, contractual obligations, or notice on a specific document.

WADC TECHNICAL REPORT 52-183
SUPPLEMENT 5
ASTIA DOCUMENT AD 142081

ANNUAL REPORT ON RESEARCH FOR USE IN ANC-17 BULLETIN "PLASTICS FOR AIRCRAFT"

DONALD G. COLEMAN

FOREST PRODUCTS LABORATORY

OCTOBER 1957

MATERIALS LABORATORY
CONTRACT NO. AF 33(616)-56-9
PROJECT NO. 7340

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Carpenter Litho & Prtg. Co., Springfield, Ohio
400 — December 1957

FOREWORD

This report was prepared by the U. S. Forest Products Laboratory under USAF Contract No. AF 33(616)56-9. This contract was initiated under Project No. 7340, "Rubber, Plastic, and Composite Materials," Task No. 73401, "Structural Adhesives". It was administered under the direction of the Materials Laboratory, Directorate of Laboratories, Wright Air Development Center, with Mr. W. E. Dirkes acting as project engineer.

This report covers work conducted from July 1956 to July 1957.

ABSTRACT

Developments in the program of research in plastics for aircraft conducted by the U. S. Forest Products Laboratory during fiscal year 1957 are summarized. The approach has been in general to derive criteria mathematically and then to check by test. Eight technical reports issued during the fiscal year are abstracted.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

R. T. SCHWARTZ
Chief, Organic Materials Branch
Materials Laboratory

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

INTRODUCTION[1]

This annual report by the U. S. Forest Products Laboratory covers developments in the program of research in plastics for aircraft conducted during fiscal year 1957. It is the sixth of such annual reports. For information on previous work in this program, see WADC Technical Report 52-183, and supplements 1, 2, 3, and 4 for fiscal years 1952 through 1956.

Item 55-1. --Bearing Properties of Glass-Fabric Epoxy Laminates

Bearing properties, including minimum edge and side distances, were presented in Reports 1824 and 1824-A for polyester laminates reinforced with glass fabric or glass mat. Report 1824-B shows the effect of thickness on bearing properties of polyester laminates. During the past year, bearing tests of epoxy laminates were completed, and the data supplement those of the three earlier reports. Tests were made of 1/8- and 1/4-inch-thick laminates reinforced with 112 or 181 glass fabric, and results are presented in Report 1824-C. The epoxy laminates were stronger in bolt-bearing than were the comparable polyester laminates.

This item is now complete.

---

[1]Manuscript released by author August 1957 for publication as a WADC Technical Report.

Item 55-2. --Properties of Glass-Fabric Epoxy Laminates

Data have been available on the mechanical properties of polyester laminates reinforced with different types of glass-fiber reinforcement and on an epoxy laminate reinforced with 181 glass fabric (Reports 1820, 1820-A, and 1820-B). Mechanical properties of parallel-laminated epoxy laminates, reinforced with 112, 120, or 143 glass fabric were obtained and results are presented in Report 1820-C. Data presented in these four reports form the basis of tensile, compressive, flexural, and shear values found in the ANC-17 Bulletin.

This item is now complete.

Item 55-3. --Interlaminar Shear Properties of Glass-Fabric Epoxy Laminates

The interlaminar shear strength of three epoxy laminates reinforced with 112, 120, or 143 glass fabric was evaluated by the block shear test. Results are presented in Report 1848-A and supplement the data in Report 1848. Comparative data on the interlaminar shear strengths of comparable epoxy and polyester laminates are limited. However, available data from block shear tests of 112 and 181 laminates indicate that the epoxy laminates generally may be expected to have somewhat higher shear strengths than polyester laminates, as Reports 1848 and 1848-A indicate.

This itemis now complete.

Item 55-4. --Effect of Tensile Preloading and Water Immersion on Flexural Properties of Glass-Fabric Polyester Laminates

Characteristically, tests of plastic laminates are made on laminates that have not been previously stressed. Earlier studies have indicated that tensile stresses may cause crazing of the resin. This crazing, combined with other possible structural changes within the laminate, might provide paths along which moisture could penetrate more rapidly and lower its resistance to weathering, as well as changing its mechanical properties from those observed in tests of laminates that had not been stressed previously. Report 1856 presents results of a preliminary study to investigate preloading effects on a typical polyester laminate. Preloading produced statistically noticeable effects on most flexural properties, but the effect was so small as to be of little or no practical significance.

A supplement to the report was prepared and submitted to the Panel for review. The supplement presents the results of flexural tests after tensile preloading to various stress levels, followed by weathering for 3 months, and for a 1 year period at Madison, Wis.

Item 55-5. --Calculation of Curves for Directional Properties of Laminates

Tensile, compressive, and shear properties of most of the reinforced plastic laminates vary with direction of loading. Equations for computing directional properties are available, but designers prefer to use curves that present directional properties graphically. Report 1803-B

presented curves for directional properties of several types of laminates. A similar report was recently completed, Report 1803-C, which presented curves for directional properties of five epoxy laminates.

This item is now complete.

Item 55-6. --Dimensional Stability of Glass-Cloth Laminates

The dimensional stability of a material subjected to changes in atmospheric conditions is important in many aircraft structural applications. Few data were available on the dimensional stability of reinforced plastic laminates. Report 1858 presents such information, as obtained from typical panels made with a polyester and a heat-resistant polyester resin.

This item is now complete.

Item 56-1. --Creep of Glass-Fabric-Base Plastic Laminates

Creep parallel and perpendicular to the warp and fill directions of parallel and cross laminates is usually negligible, but creep at other angles may be appreciable. Creep and creep-rupture data were obtained for typical polyester and epoxy laminates, including results of tests at 45° to the warp direction. A final report is expected to be available early in fiscal year 1958.

Item 56-2. --Fatigue Properties of Glass-Fabric-Base Epoxy Laminates at Various Angles of Loading

Considerable data were available on the results of axial fatigue tests at 0° and 90° to the warp direction, but only limited data at 45°. Because

of the variation in mechanical properties with direction of loading, aircraft designers require information pertaining to directional fatigue properties. During the past year, axial fatigue tests of a typical epoxy laminate were completed at 0°, 15°, 30°, and 45° to the warp direction, for which both notched and unnotched specimens were used. Results are presented in Report 1823-B.

This item is now complete.

Item 56-3. --Fatigue Properties of Glass-Fabric-Base Epoxy Laminates Loaded in Bearing

Limited data indicated that the fatigue properties of a laminate loaded in bearing are similar to those of a notched, axially loaded specimen. Additional bearing fatigue tests of a typical epoxy laminate were completed under both normal and wet conditions. Results are presented in Report 1823-B, along with the results of tests conducted under Item 56-2. The bearing fatigue S-N curve for normal conditions was slightly lower than the corresponding curve for notched fatigue specimens; but for wet conditions the curves were about the same.

This item is now complete.

Item 56-4. --Determination of Poisson's Ratios for Various Glass-Fabric-Base Plastic Laminates

This work was undertaken to provide reliable values of Poisson's ratios for typical glass-fabric laminates. Previous data were limited, and the

available data from various sources were not consistent. The results of the tests and the Poisson's ratios for several typical laminates are presented in Report 1860. For most of the laminates investigated, Poisson's ratios were about 1/8 for loads applied parallel or perpendicular to the warp direction.

Item 57-1. --Revision of ANC-17 Bulletin

Since submission of the final draft of part I of the ANC-17 Bulletin in February 1955, considerable additional data have become available that relate to the design of reinforced plastics for aircraft. These data were reviewed and analyzed, and a preliminary draft of a revised bulletin was prepared.

Item 57-2. --Properties at Elevated Temperatures of Glass-Fiber-Reinforced Laminates Made with Heat-Resistant Resins

Work on this item was deferred in order that a more complete analysis could be made of the available data and work could be better planned and coordinated.

Item 57-3. --Effect of Thickness of Epoxy Laminates

Previous work at the Forest Products Laboratory has shown that the mechanical properties of reinforced plastic laminates are less for thin than for thick laminates within the range of 0.01 to 0.25 inch. At thicknesses below about 0.03 inch, strength properties decreased rapidly with decreasing

thickness. Experience has also indicated that relatively thick laminates, say 1 to 1-1/2 inches, also have lower properties than typical 1/8 or 1/4-inch laminates. Comparative tests were started of carefully matched epoxy laminates of 1/8 and 1-1/2 inches.

Item 57-4. --Effect of Tensile Preloading on the Tensile and Compressive Properties of a Typical Epoxy Laminate

Previous data have shown that tensile preloading will affect the tensile properties of polyester laminates. No data are available, however, on the effects of preloading on epoxy laminates. This item is designed to furnish data on the effects of tensile or compressive preloading on subsequent tensile, compressive, and shear properties. Some of the required laminates were fabricated, and testing of specimens was started.

Item 57-5. --Effect of Stress Concentration on Fatigue Strength

Available data indicate that reinforced plastic laminates are not nearly so sensitive to external stress risers as are many other materials. Axial fatigue tests of notched and unnotched specimens, showed that the notch (a centrally drilled hole), generally reduced the fatigue strength but it did not reduce it to the extent that might have been expected. Other types of notches may have more severe effects. This project is designed to investigate the effect of type of notch on the tensile strength of laminates, and will be followed by some axial fatigue tests. Most of the static tensile tests have been completed.

Item 57-6. --Design Data for a Silicone Laminate

Mechanical properties at room temperature for several types of polyester, phenolic, and epoxy laminates are presented in Reports 1820, 1820-A, 1820-B, and 1820-C. Work planned under this item will provide similar data for a typical silicone laminate. The laminated panel was fabricated, and many of the tests have been completed.

REPORTS ON RESEARCH IN PLASTICS FOR AIRCRAFT ISSUED BY U. S. FOREST PRODUCTS LABORATORY DURING FISCAL YEAR 1957

FPL Report No.	Title
1803-C	Supplement to Directional Properties of Glass-Fabric-Base Plastic Laminate Panels of Sizes That Do Not Buckle.
	Presents graphical relations between properties and direction of loading for tension, compression, and shear for several epoxy laminates.
1820-C	Supplement to Mechanical Properties of Plastic Laminates.
	Presents the results of tension, compression, and bending tests of three different parallel-laminated epoxy laminates reinforced with 143, 112, or 120 glass fabric. The data supplement those of Forest Products Laboratory Report Nos. 1820, 1820-A, and 1820-B.
1823-B	Supplement to Fatigue Tests of Glass-Fabric-Base Laminates Subjected to Axial Loading.
	Presents the results of fatigue tests of an epoxy laminate subjected to axial loading. Direct stress tests were made at 0°, 15°, 30°, and 45° to the warp direction. A few bearing fatigue tests at 0° loading are also reported.
1824-C	Supplement to Bolt-Bearing Properties of Glass-Fabric-Base Plastic Laminates.
	Presents the results of bolt-bearing tests of two parallel-laminated glass-fabric-base epoxy laminates. The data supplement those of Forest Products Laboratory Reports Nos. 1824, 1824-A, and 1824-B.
1848-A	Supplement to Interlaminar Shear Strength of Glass-Fiber Reinforced Plastic Laminates.
	Presents the results of interlaminar shear tests of three parallel-laminated epoxy laminates reinforced with 112,

FPL Report No. | Title

120, or 143 glass fabric. Tests were made with block shear test. Data supplement those reported in Forest Products Laboratory Report 1848.

1856 Effects of Tensile Preloading and Water Immersion on Flexural Properties of a Polyester Laminate.

Strips from a typical polyester laminate were subjected to various levels of tensile preloading, followed by exposure, either stressed or unstressed, to normal exposure or water immersion. Results of flexural tests after exposure are presented.

1858 Dimensional Stability of Glass-Cloth-Reinforced Laminates.

Presents data on moisture-induced dimensional changes, rate of moisture pick-up, and thermal coefficients of expansion for typical polyester and heat-resistant polyester laminates.

1860 Poisson's Ratio for Glass-Fabric-Base Plastic Laminates.

Presents values of Poisson's ratios determined from tension tests of several typical glass-fabric laminates.